ON PROTOPLASMIC LIFE,

AND THE ACTION

OF

HEAT AND ANTISEPTICS UPON IT.

BY

DR. F. CRACE-CALVERT, F.R.S., F.C.S.,

Corresponding Member of the Royal Academy of Turin, of the Medical Society of Brussels, the Industrial Society of Mulhouse, Honorary Member of the Pharmaceutical Societies of London and Paris, &c., &c.

MANCHESTER:
W. H. CLEGG, PRINTER AND STATIONER, 11, SPRING GARDENS.

1873.

Digitized by the Internet Archive
in 2019 with funding from
Wellcome Library

https://archive.org/details/b30572307

ON PROTOPLASMIC LIFE.

(Read before the Royal Society on the 29th of February, 1871.*)*

The publication of several papers by eminent men of science, and especially the interesting one of Dr. Tyndall on the abundance of germ-life in the atmosphere, suggested the inquiry as to whether or not the germs existing or produced in a liquid in a state of fermentation or of putrefaction could be conveyed by the atmosphere to a liquid susceptible of entering into such a state; and although at the present time the results of this inquiry are not sufficiently complete for publication, still I have observed some facts arising out of the study of protoplasmic life which I desire to lay before the Royal Society.

Although the perusal of papers by many workers in this field prepared one to expect difficulties in prosecuting the study, I must confess I did not calculate on encountering so many as I met, especially those arising from the rapid development of germ-life, of which I have seen no notice in the papers which have come under my observation. During the months of August and September, if the white of a new-laid egg be mixed with water (free from life) and exposed to the atmosphere for only fifteen minutes, the presence of life can be detected. I regret to state that not being aware of this fact I was misled in many of my earlier experiments, not having been sufficiently careful to avoid exposure of the fluids to the atmosphere, even for a few minutes, before making their microscopic examination, and I have no doubt that the erroneous conclusions arrived at by several gentlemen who have devoted their attention to the subject of spontaneous generation may also be thus explained.

I believe that I have overcome the difficulty of the fluids under examination becoming polluted by inpregnation with the protoplasmic life existing in the atmosphere, by adopting the following simple method:

As a neutral fluid free from life was essential to the carrying out of the investigation, I directed my attention to preparation of pure distilled water. Having always found life in distilled water prepared by the ordinary methods, when kept a few days, I devised, after many trials, the following apparatus, which gave very satisfactory results, and enabled me to obtain water which remained free from life for several months.

It consists of two flasks, A and B (A rather larger than B), fitted with perforated caoutchouc stoppers.* These flasks are connected by the tube D. Into the stopper of A is fitted a tube C, to which is joined a piece of caoutchouc tubing, which may be closed by the clip E. Through the stopper of B is a syphon, F, the long limb of which is cut and joined with caoutchouc tubing, which can be closed by the clip G. Through this stopper is a third tube, H, connected by caoutchouc with the tube I; this can be closed by the clip K. The tube I is about 3 feet long, and goes into the vessel L, which is partly filled with water.

The water to be distilled is mixed with solution of potash and permanganate of potash, and placed in the flask A.† Before distillation is commenced, a rapid current of pure hydrogen or some other gas must be passed through the apparatus by the tube C to displace the air and carry off all the germs the air may have contained. The clip G is first left open, then this closed and the clip K opened, which allows the gas to pass through the water in the vessel L.

The gas should be passed through for about fifteen minutes. The clip E is then closed, and the distillation carried on. When the operation is complete, the gas must be again passed through the apparatus, and the connection with the tube I broken by closing the clip K. The water is drawn off through the syphon F. The long tube acts as a safety-tube, and is made so long that the absorption is noticed in ample time to close the clip before any air can enter through that tube.

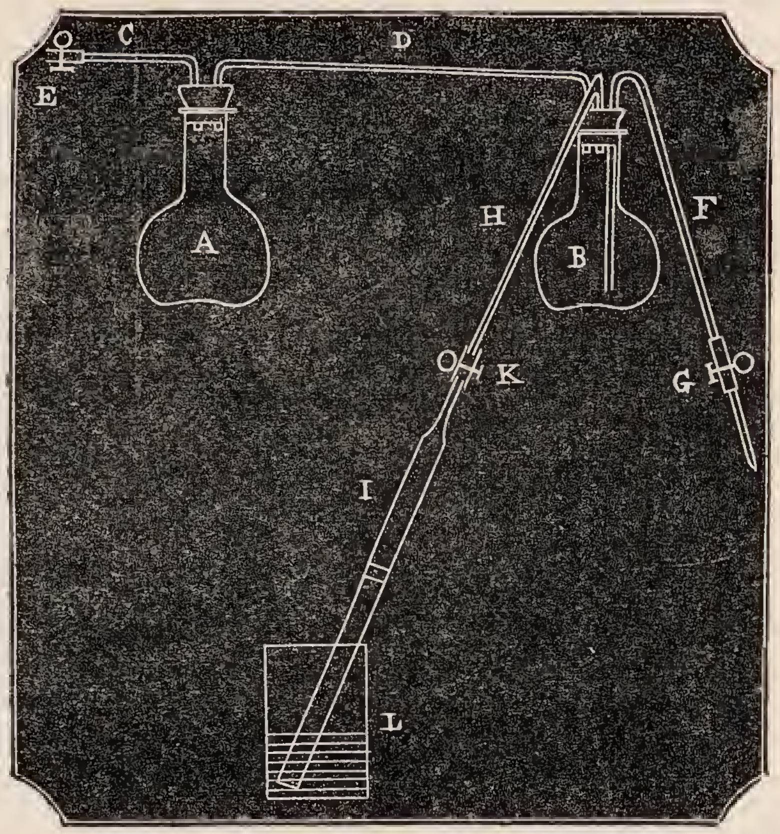
The water has to be re-distilled three or four times before it is obtained free from germs, and must be kept in the apparatus in which it is distilled until wanted, to prevent any contact with air.

Some water which had been distilled on the 20th of September, 1870, and was still free from life on the 7th of December, was introduced by the syphon H into twelve small tubes, and left exposed to the atmosphere for fifty hours, when the tubes were closed. Every eight days some of the tubes were opened, and their contents examined. Therefore, on the eighth and fifteenth days examinations were made, when no life was observed ; on the twenty-first, two or three other tubes were examined, and again no life was detected; whilst in the series opened on the 2nd of January, 1871 (that is to say, twenty-four days from the time the tubes were closed), two or three black vibrios were found in each field.

---

* The stoppers and caoutchouc tubing used for the various joints must be new, and must be well boiled in water before use.

† The reasons why I employed permanganate of potash (in large excess) were that, under the influence of heat, its oxidising powers were much increased, and that it gave off no gas that could interfere with the purity of the water; further, a solution of the salt not even yielding oxygen when boiled.



Being impressed with the idea that this slow and limited development of protoplasmic life might be attributed to the small amount of life existing in the atmosphere at this period of the year,* a second series of experiments was commenced on the 4th of January. The distilled water in the flask being still free from life, a certain quantity of it was put into twelve small tubes, which were placed near putrid meat at a temperature of 70° to 80° F. for twelve hours, and then sealed. On the 10th of the same month the contents of some of the tubes were examined, when two or three small black vibrios were observed under each field. This result shows that the fluid having been placed near a source of protoplasmic life, germs had introduced themselves in twelve hours in sufficient quantity for life to become visible in six days instead of twenty-four. Other tubes of this series were opened on the 17th of January, when a slight increase of life was noticed;

---

* During the intense cold weather of last December, I found it took an exposure to the atmosphere of two days, in a room having a temperature of 12° C., before life appeared in a solution of white of egg made with pure distilled water, whilst as the weather got warmer the time required became less.

but no further development appeared to take place after this date, as some examined on the 10th of March did not contain more life than those of the 17th of January.

This very limited amount of life which had been observed suggested the idea that it might be due to the employment of perfectly pure water, and that the vibrios did not increase, owing to want of the elements necessary for sustaining their life. I therefore commenced a third series of experiments. Before proceeding to describe this series, I must call attention to the fact that the water in the flask had remained perfectly free from life up to this time, a period of nearly sixteen weeks.

On the 9th of February 100 fluid grains of albumen from a new-laid egg were introduced, as quickly as possible and with the greatest care, into 10 ounces of pure distilled water, free from life, and contained in the flask in which it had been condensed, and an atmosphere of hydrogen kept over it. On the 16th some of the fluid was taken out by means of the syphon F, and examined, and no life being present, twelve tubes were filled with the fluid, exposed to the air for eight hours, and closed. On the 21st the contents of some of the tubes were examined, when a few vibrios and microerphymes were distinctly seen in each field. On the 27th other tubes were examined, and showed a marked increase in the amount of life. In this series life appeared in five days, and an increase in ten, instead of requiring twenty-four days, as was the case when pure water only was employed.

Albumen, therefore, facilitated the development of life. Of course the contents of the flask were examined at the same time, but in no instance was life detected. I believe that these three series of experiments tend to prove the fallacy of the theory of spontaneous generation; for if it were possible, why should not life have appeared in the pure distilled water, or in the albuminous solution, which were kept successively in the flask B, as well as in the fluids which were contained in the tubes, and had been exposed to the atmosphere or near animal matter in a state of decay, and had thus become impregnated with the germs of protoplasmic life? What gives still further interest to these experiments is that, having operated during the severe weather of last winter, when little or no life existed in the atmosphere, I was able to impregnate the fluids with germs without introducing developed life, as was ascertained by examining some of the fluids in the small tubes before closing them.

The quantity of life produced in the above-recited experiments being comparatively small, I was led to infer that this might be due to the influence of the atmosphere of hydrogen employed to displace the air in the apparatus used for obtaining the water. I, therefore, on the 2nd of March, prepared a solution of albumen similar to that before employed, but expelled the air out of the apparatus by pure oxygen; and as the contents of the flask B were free from life on the 8th of March, a series of small tubes were filled and exposed for twenty-six hours to the atmosphere near putrid matter, and then sealed. Several of these tubes were opened on the 11th, and immediately examined, when only a few cells were observed in each field. A second lot was opened on the 14th, and they showed considerable increase of life, there being two or three vibrios under each field. A third quantity was opened on the 25th, when no increase had taken place. This latter result tends to show that although oxygen appears to favour the development of germs, still it does not appear to favour their reproduction.

As the weather had become much warmer, and a marked increase of life in the atmosphere had taken place, some of the same albumen solution employed in the above experiments was left exposed in similar tubes to its influence, when a large quantity of life was rapidly developed and continued to increase. This result shows that the increase of life is not due to reproduction merely, but to the introduction of fresh germs; for, excepting this fresh supply, there appears to be no reason why life should increase more rapidly in the open than in the closed tubes.

ON PUTREFACTION.

This paper is intimately connected with that on Protoplasmic Life, and in which I have endeavoured to show that putrefaction is probably due to it.

I have already shown* that when albumen from a new-laid egg is carefully introduced into pure distilled water, and the solution is excluded from the atmosphere, protoplasmic life does not appear; but, if the same solution be exposed to the air for from fifteen to forty-five minutes, then minute globular bodies appear, having an independent motion, which I shall call microphymes. The time required for the life to appear varies according to the period of the year, the amount of moisture present in the atmosphere, and the temperature.

Although M. Pasteur has noticed the meteorological conditions which influence that life, still he did not observe the extraordinary rapidity with which fluids are impregnated, and that the impregnation is proportional to the surface exposed. And that such is the case is proved by the following experiment:—On the 18th of May, 1871, two portions of an albumen solution, each measuring four hundred grains, were placed, the one in a test-tube having a diameter of three quarters of an inch, the other in a test-glass, which had a diameter of two inches at the surface of the liquid. In the tube vibrios were not developed until after twelve days, while in the glass only five days were required for their appearance.

Another illustration of the abundance of this life may be cited. If, in place of pure distilled water, the water supplied by the Manchester Corporation be mixed with albumen and placed in a test-tube, instead of the time required for development ot vibrio life being twelve days, only twenty-four hours are necessary.

In the hope of throwing some light on the question of the necessity of the presence of oxygen for the maintenance and reproduction of this life, the following experiments were made:

---

* Proc. Roy. Soc., Vol. xix., p. 471.

Into five glass bulbs equal volumes of a solution of albumen in Manchester water were introduced. One of these bulbs was left in contact with the atmosphere for twenty-four hours, after which the ends of the tube were hermetically sealed at about two inches on each side of the bulb. After passing oxygen, hydrogen, nitrogen, and carbonic acid over the other four solutions respectively, the tubes were also hermetically sealed. These bulbs were kept closed for twenty-seven days, during which it was observed that the albumen in the bulb containing oxygen speedily became turbid, and, later, the one containing air, while the other three remained clear. At the expiration of this period the tubes were broken and the contents examined. A large quantity of vibrio life was found in those containing oxygen and common air, whilst those containing nitrogen, carbonic acid, and hydrogen showed very small quantities of vibrios, hydrogen the least, thus proving oxygen to be essential to the development of putrefactive vibrios. During these experiments a striking instance occurred of the efficacy of oxygen in the development of vibrio life. A small crack was observed in one of the hydrogen bulbs, and it was found that by diffusion enough air penetrated to develope an active growth of animalcule life.

In further support of the view that oxygen is necessary to the existence and development of this life, I may state that under certain conditions these animalcules produce such an amount of carbonic acid and other gases as to exclude oxygen to such an extent that their own development and life is impaired. If an albumen solution full of animalcules, but not emitting any putrid odour, be placed in test-tubes, and some of the tubes be closed while others are left open, it will be found after a few weeks that in those left in the air life has much increased, and that they emit a very putrid odour—whilst the life in the closed tubes not only has not increased, but appears to be in a dormant condition; for, on the latter fluids being again brought in contact with the oxygen of the atmosphere, their activity returns. The albumen in the closed tubes does not emit any putrid odour.

M. Pasteur has made the remarkable observation that oxygen destroys peculiar classes of vibrios or Bactœria, which exist in butyric fermentation.

Having already stated that liquids exposed to the atmosphere become impregnated with microphymes, I will proceed to describe their gradual development into vibrios, and their ultimate transformation into what I call microerphymes. Figure 1 represents it a few hours after a liquor becomes impregnated; microphymes, which have a diameter of about the one hundred and twenty-eight thousandth part of an inch, appear to agglomerate and form masses, as shown in figure 2. Some of the microphymes then become elongated into vibrios, which, though attached to the mass, have an independent motion, and as the force exerted by the vibrios predominates towards one or another direction, so is the mass moved over the field of the microscope. Their appearance is represented in figure 3. As the development proceeds the mass is broken up, and at last each vibrio has an independent existence, and may be seen swimming or rolling about the fluid. The changes may be seen in figures 4 and 5. Their size is about the twenty thousandth part of an inch. These I call ordinary vibrios. They gradually grow into long vibrios, which attain a length of the six thousandth of an inch. These are represented by figure 6.*

These long vibrios gradually become changed into cells, which I have called microerphymes. The first process in the transformation is the division of the vibrio into two independent bodies or parts. At first an extremely faint line appears across the centre of the animalcule, and gradually increases in distinctness until the vibrio appears like two smaller vibrios joined together. The separation takes place, and each part acquires an independent existence. These parts again divide, and the process of subdivision is carried on until they appear to be nothing more than cells, having a swimming power which enables them to pass over the field of the microscope with great rapidity. These I call microerphymes. The changes I have endeavoured to represent in figure 7.

After twelve or eighteen months all the vibrios disappear, and are replaced by microerphymes, either in motion or at rest. If they are placed in a solution of fresh albumen, vibrios are again abundantly developed. The probable explanation of this fact is, that in the fresh albumen they have all the circumstances favourable to their growth and reproduction, whilst the putrid albumen has become so completely modified as to be incapable of affording them the requisite conditions of reproduction. Thus, when albumen has undergone complete putrefaction, through the influence of microscopic life, its properties are quite altered; a deposit has taken place which, under the microscope, appears to consist of shoals of small particles of matter which have no life, whilst the supernatant solution has become perfectly clear, possesses considerable refractive power, and has lost the property of becoming coagulated by heat.

---

* See plate at end of pamphlet.

Further, no albumen solution emits a putrid odour until the above-mentioned deposit has made its appearance, and its degree of putrescence is always in direct ratio to the number of vibrios present.

During these investigations other animalcules were observed.

Where vibrios are found there often appear bodies which have a resemblance to vibrios, but which are not identical with them, for they are straight, motionless, and comparatively opaque. Whether they are a variety of vibrios, or animals of a distinct class altogether, or Bactœria, I have as yet been unable to determine.

I will now give a description of some forms of life which I have noticed in special cases.

When the outside of the shell of a fresh egg is washed with distilled water, and the washing mixed with a solution of albumen, after about nine days, not only a large quantity of vibrios exist, but peculiar animalcules will be found having the appearance of *lozenge-shaped* discs, although they have in reality a spheroidal form. This animalcule has a *cilium* several times the length of its body, which it moves with great rapidity as it passes over the field of the microscope. When fully developed the body has a length of the three thousandth of an inch. It is shown in figure 8.

This animalcule is also observed in other circumstances, viz., in the flocculent precipitate which takes place in an albumen solution in which a large quantity of vibrios have existed. At first there appears a large quantity of motionless cells, which gradually acquire an independent motion. After some time, they separate from the amorphous deposit, and develope into a peculiar animalcule. The drawing, figure 9, will give an idea of it.

When these animalcules are developed in large numbers the vibrios lose their power of motion and appear to be quite dead, as they oscillate in the current produced in the fluid by the motion of these peculiar animalcules. At the same ime a much larger quantity of offensive gases are given off than is the case when vibrionic putrefaction only takes place. It is probable, therefore, that they have a greater power of absorbing oxygen than vibrios, and thus, either by the want of oxygen in the liquid or by the presence of noxious gases, the vibrios die.

In the same fluid may often be observed animalcules having a similar appearance to the one just described, but having two cilia instead of one, as will be seen by reference to figure 10.

These two classes of animalcules may also be observed in sewage, and in water which has been in contact with leaves in a state of decay.

A very active agent of putrefaction are transparent cells, which I call "putrid cells." These cells may be of various sizes from a mere point to comparatively large cells, as represented in figure 11. Often inside a large cell a number of small ones are observed, which gradually increase in size until they appear to burst the parent cell and have an independent existence.

When these putrid cells develope in an albuminous solution, and they render it milky and turbid, it emits a bad putrid odour.

I shall now call attention to the decomposition of animal matter by means of a fungus.

If an albumen solution be left exposed to the air, there soon appears in it a fibrous mass, which gradually increases until the filaments become interwoven, and when viewed under the microscope has the appearance shown in figure 12.

The spores of this fungus must be abundant in the atmosphere, as the fungus, which I believe to be *mycilium,* generally appears in an albuminous solution when exposed to the atmosphere. This fungus, like the above-mentioned animalcule life, absorbs oxygen and emits carbonic acid, which explains why it cannot develope in a liquid containing a large quantity of vibrionic life, and conversely why, in a liquid containing a large quantity of this fungus, vibrios cannot increase.

This fungus is always found under the surface of the albuminous liquid, whilst grape-like bodies are observed to float on the surface; they are not, I believe, the spores of the mycilium, but another variety of fungus, when in large quantities always emits a mouldy odour, particularly so when it dries up and assumes the appearance represented in figure 14. It is so light that it is dispersed by blowing.

Lastly, there is another fungus which I have found in several fluids, and always growing among the filaments of mycilium. It has a blood-red colour, which it gradually imparts to the fluid in which it grows. It is easily affected by external causes, losing its bright colour and becoming dark. It has no distinct structure, and has the appearance represented in figure 15.

4.—*Putrid Albumen in Oxygen.*

A series of experiments was instituted, with the view of ascertaining the exact action which vibrios exert on the decomposition of a solution of putrid albumen when placed in an atmosphere of oxygen. To effect this, a small quantity of putrid albumen was mixed with some fresh albumen, and four ounces of such fluid were introduced into a corked bottle, which was then filled with an atmosphere of pure oxygen.

The gaseous contents were ultimately submitted to analysis, and gave the following results :—

Oxygen	37·609	36·857
Carbonic Acid	57·550	57·760
Nitrogen	2·990	3·350
Hydrogen	1·851	2·033
Hydrosulphuric Acid	trace	trace
	100·000	100·000

It is interesting to observe that hydrogen and nitrogen are given off in the putrefaction of albumen, as their presence proves that this decomposition is not due to a purely chemical or molecular change, for then we could not have these gases in a free state; but that they are generated by microscopic animal life, which unfolds albumen into other substances, which present properties different to those of albumen, as stated in one of my previous papers. Thus, one part of the original albumen has become insoluble; another remains in solution, and has quite different properties to albumen; and lastly, a third portion of the albumen has been consumed by the vibrios. Whether the gaseous products given off during these changes, as above stated, are the refuse products of the life of vibrios, or secondary products of the unfolding of albumen by vibrios, in the same way as sugar is unfolded under the vital action of the torula into carbonic acid and alcohol, is yet a question which remains to be solved.

The putrid fluid was next submitted to careful microscopic examination, and it was observed that nearly the whole of the vibrios were lifeless, for they floated about in accordance with the movement imparted to the fluid; and that only a few could be detected which had distinct self-motion, and were capable of swimming across the field.

The above experiments confirm my previous statement that the vitality of vibrios is destroyed by the gases which they generate. (See pages 38 and 50.)

ACTION OF HEAT ON PROTOPLASMIC LIFE.

Those investigators of germ-life who favour the theory of spontaneous generation have assumed that a temperature of 212° F., which is the boiling-point of the fluid which they have generally experimented upon, was sufficient to destroy all microscopic animal life, and that the life they subsequently observed in these fluids was developed from non-living matter.

I therefore made several series of experiments, in the hope that they might throw some light on the subject.

The first series was made with a sugar solution, the second with an infusion of hay, the third with solution of gelatine, and the fourth with water that had been in contact with putrid meat. The hay and putrid-meat solutions were taken because they had often been used by other investigators; sugar was employed, being a well-defined organic compound free from nitrogen, and which can easily be obtained in a state of purity; and gelatine was selected as a nitrogenised body which can be obtained pure and is not coagulated by heat.

To carry out the experiments, I prepared a series of small tubes made of very thick and well-annealed glass, each tube being about four centimetres in length, and having a bore of five millimetres. The fluid to be operated upon was introduced into them, and left exposed to the atmosphere for a sufficient length of time for germ-life to be largely developed. Each tube was then hermetically sealed and wrapped in wire gauze, to prevent any accident to the operator in case of the bursting of any of the tubes. They were then placed in an oil-bath, and gradually heated at various fixed temperatures, at which they were maintained for half an hour.

Sugar Solution.—A solution of sugar was prepared by dissolving 1 part of sugar in 10 parts of water. This solution was made with common water, and exposed all night to the atmosphere, so that life might impregnate it. The fluid was prepared on the 1st of November, 1870, introduced into tubes on the 2nd, and allowed to remain five days. On the 7th of November twelve tubes were kept without being heated, twelve were heated to 200° F., twelve to 300°, and twelve to 400° F.

The contents of the tubes were microscopically examined on the 1st of December, twenty-four days after heating. (See Table, page 18.)

The black vibrios referred to in these tables are far more opaque than the other varieties of vibrios, and are the most important of all, as I have found them to resist not only very high temperature, but all chemical solutions. I shall, in my paper on putrefaction and the action of antiseptics, describe the various vibrios and give drawings of them.

Hay Infusion.—An infusion of hay was made by macerating it in common water for one hour, then filtering the liquor, and leaving it exposed to the atmosphere all night, when it was sealed in the small tubes, twelve of which were used for each experiment. The infusion was made on the 4th of November, sealed in tubes on the 5th, and heated on the 7th.

The results were examined on the 1st of December, 1870, twenty-four days after being heated. (See Table, page 18.)

Gelatine Solution.—A solution of gelatine, prepared of such strength that it remained liquid on cooling, was exposed for twenty-four hours to the atmosphere. It was then introduced into the small tubes, and sealed. The solution was made on the 4th of November, the tubes sealed on the 5th, and subjected to the different temperatures on the 7th.

The fluids were examined on the 1st of December, 1870, twenty-four days after being heated. (See Table, page 19.)

Putrid-Meat Fluid.—Water was placed in an open vessel, and a piece of meat suspended in it until it became putrid and contaminated with myriads of animalcules; it was then dipped into distilled water, and this fluid was placed into the small tubes, sealed on the 7th of November, and heated on the same day.

The contents of the tubes were subjected to examination on the 1st of December, or twenty-four days after having been heated. (See Table, page 19.)

The general conclusion to be drawn from the above four Tables is that protoplasmic life is but slightly affected by a temperature of 212° F., and that even at a temperature of 300° F., it is not entirely destroyed, excepting in the case of gelatine, and that a temperature of 400° F. is necessary to completely destroy life in all the other fluids. These experiments, therefore, clearly show that the animal life found by previous experimenters in fluids which have been submitted to heat was not necessarily due to heterogenesis, but might be owing to the life which had remained in the fluids after having been treated, and I am justified in the conclusions, as I have seen no experiment reported where the temperature to which the fluids were exposed exceeded 300° F.*

I am the more justified in making this statement, as I have repeatedly examined the contents of tubes which had been submitted to a temperature of 400° F., both immediately after cooling and at various intervals up to thirty days, and was unable to detect the slightest trace of life.

This result corroborates those recorded in my previous paper, and proves that the spontaneous-generation theory cannot be maintained.

It further occurred to me that it might be interesting to examine if the putrid-meat fluids that had been heated still possessed the property of propagating life. To enable me to throw light on this point a solution was prepared by mixing the albumen of a new-laid egg with pure distilled water free from life (prepared as described in my previous paper), and equal volumes of this solution were placed in six small test tubes, (which had been cleansed with hot vitriol and well washed with pure water). To one tube were added two drops of the putrid-meat solution, which had been heated to 100° F., to a second two drops of that heated to 212° F., to a third two drops of the liquid heated to 300° F., to a fourth an equal bulk of fluid heated to 400° F., and to a fifth the same quantity heated to 500° F. In the sixth the original albuminous solution was kept for comparison.

The tubes were then sealed, and kept from the 1st of February to the 9th.

Results of Examination.

Albumen solution.	Albumen solution, with putrid-meat liquor, heated to 100° F.	Albumen solution, with putrid-meat liquor, heated to 212° F.	Albumen solution, with putrid-meat liquor, heated to 300° F.	Albumen solution, with putrid-meat liquor, heated to 400° F.	Albumen solution, with putrid-meat liquor, heated to 500° F.
No. life.	Abundance of life.	Abundance of life.	Much less life than in the two previous fluids.	In each drop only 2 or 3 small black vibrios, moving to and fro.	In each drop only 2 or 3 small black vibrios, moving to and fro.

---

* It is with pleasure that I find these experiments to confirm the suggestion of Dr. Beale, in his work entitled "Disease Germs, their Supposed Origin," page 50 (which I read a few weeks ago), that "living forms might live, though exposed, under certain conditions, to a temperature of 350° F."

These results clearly show that, at the temperature of 100°, 212°, and 300° F., life and its germs had not been destroyed, whilst at 400° F. they had; for the results of the examination were in this case exactly identical with those of the albumen solution itself; therefore I conclude that the life found was doubtless introduced during the preparation of the solution, and was not due to any life having remained in the fluids that had been heated, as it was in these cases far more abundant.

Although perfectly aware of the interesting researches of Professor Melsens, proving that the most intense cold does not destroy the active power of vaccine lymph, still I thought it desirable to ascertain the effect of a temperature of 15° F. on well-developed germ-life, similar to that which had been subjected to the action of heat; therefore some putrid-meat liquor, containing a large quantity of microzyma and vibrios, was subjected for twenty hours to the influence of a temperature ranging between the freezing-point of water and 17° below that point, when the ice was melted, the liquor examined, and it was found that the animalcules had retained their vitality, but appeared very languid, and their power of locomotion had greatly decreased.

Two hours after melting the ice the liquor was again examined, when the animalcules appeared to be as energetic as before.

Table No. 1.

Sugar Solution. not heated.	Heated for half an hour at 212° F.	Heated for half an hour at 300° F.	Heated for half an hour at 400° F.	Heated for half an hour at 500° F.
There were about 30 animalcules under each field of the microscope, principally *small black vibrios*, 3 or 4 *ordinary swimming vibrios*, a few Bacteria, and a few microzymes.	A great portion of the life had disappeared, no animalcules were swimming; still this temperature had not completely destroyed life. 4 to 5 *small black vibrios* were observed moving energetically to and fro; 2 or 3 *ordinary vibrios* were also observed moving, but not swimming about.	The sugar was slightly charred, but the life was not entirely destroyed, as 1 or 2 *ordinary vibrios* and 1 or 2 *small black vibrios* were observed in motion under the field of the microscope.	The sugar was almost entirely decomposed; no trace of life was observed.	No life observed.

Table No. 2.

Hay infusion not heated.	Heated for half an hour at 212° F.	Heated for half an hour at 300° F.	Heated for half an hour at 400° F.	Heated for half an hour at 500° F.
Fungus matter was observed growing on the surface of the fluids in two of the tubes. On subjecting the contents of some of the tubes to examination, from 20 to 25 animalcules were observed under each field of the microscope, principally microzyma and one or two ordinary vibrios.	No fungus matter was noticed on the surface in any of the tubes. A few small black vibrios were present as in the original solution.	No fungus matter present, but some of the small black vibrios were still present, although in less numbers.	No fungus matter observed. The fluid was filled with irregular masses of coagulated matter, but life had disappeared.	No life present.

TABLE No. 3.

Gelatine solution not heated.	Gelatine solution heated for half an hour at 100° F.	Heated for half an hour at 212° F.	Heated for half an hour at 300° F.	Heated for half an hour at 400° F.
There were seven or eight animalcules under each field, five or six of which were quite different to any thing observed in the other fluids. They had long thin bodies, and were swimming with a peristaltic motion. One or two ordinary vibrios were also present; but the black vibrios were absent.	Life seemed to have only slightly decreased, and none of the animalcules were swimming. The peculiar animalcules mentioned in the first column appeared to retain still its peristaltic motion, but not sufficient power to move across the field, a few ordinary vibrios were observed moving to and fro.	A very decided diminution of life was recorded.	No life present.	No life present.

TABLE No. 4.

Putrid meat solution not heated.	Heated for half an hour at 100° F.	Heated for half an hour at 212° F.	Heated for half an hour at 300° F.	Heated for half an hour at 400° F.	Heated for half an hour at 500° F.
A large quantity of life was present—namely, microzyma and several distinct species of vibrios, among which were a number of the small black ones frequently mentioned.	This temperature had but slightly affected the life present; the animalcules being as numerous as in the liquid not heated. However, some long vibrios appeared considerably affected, as they were much more languid in their movements.	This liquid differed from those previously examined, being turbid and coagulated. Life was still present; and although heat had deprived the animalcules of the power of locomotion, still they retained a sufficient amount of vital force to place it beyond a doubt that life was not destroyed.	The liquid was quite clear, the albumen (which is coagulated at 200°) appeared to be re-dissolved. A large quantity of the life in the fluid was destroyed, but some vibrios still remained, the small black ones being the most numerous.	All life had disappeared.	All life had disappeared.

ON THE EFFECTS OF HEAT ON PROTOPLASMIC LIFE, PREVIOUSLY DRIED.

The following series of experiments was instituted as a sequel to those already published, and with the view of ascertaining whether animalcules which had been previously dried would resist a higher temperature without being destroyed than animalcules when heated *with* the fluid in which they were living.

In hope of throwing some light on this point, small thin slips of glass, three centimetres in length and five m.m. in breadth, were taken, and one side of each slip was smeared with a thin coating of putrid albumen containing a considerable quantity of microscopic life.

Fifty-six of these slips of glass were prepared on the 5th of July, 1871, and allowed to dry in the air for twenty-four hours, when twenty-eight of them were taken and sealed in tubes of the same size as those used in the experiments already cited, whilst the remaining twenty-eight were placed in an air-bath, and kept at a temperature ranging between 212° and 220° F. for fourteen hours, and then introduced in tubes and sealed.

Therefore there are two series of experiments—one in which the putrid fluid was merely dried on the slips at natural temperature; the other in which the fluid, after being dried in the air, was heated to 212° F. for 14 hours.

Four tubes from each series were set apart; the remaining tubes of both of the series were enveloped with wire gauze, and placed in an oil-bath, which was gradually heated and kept for half an hour at the following temperatures:—100° 200°, 300°, 400°, 500°, and 600° F. Four tubes from each series were taken out at each temperature, and those that remained were kept in the bath with its temperature at another fixed point for half an hour. The results of these experiments are given on pages 15 and 16, and are similar to those already recorded on pages 22 and 23.

Experiments were also made with the view of ascertaining if the germs of microscopic animal life were destroyed at the same temperatures as the animalcules themselves, and the results are given on pages 24 and 25. The facts observed prove that the germs in an aqueous solution do not appear to have a greater vitality than the animalcules themselves.

A further series was made substituting a solution of albumen free from life for the water used in the last experiments, the purpose being to facilitate the development of life by the employment of a fluid favourable to the maintenance of such life.* The tables given on pages 26 and 27 shew that the results are the same as with water.

---

* It is an interesting fact, which I believe is not generally known, that albumen, although coagulated in a solution below 212° F., redissolves again when heated under pressure at a temperature between 300° and 400°.

Series I.—Slips (*dried in air*) and heated at the various temperatures. Moistened with water on the slide of the microscope, and examined after fifteen minutes.

Not heated.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1.	2.	3.	4.	5.	6.	7.
Six or seven living animalcules were present under each field. All were moving to and fro. The majority are ordinary vibrios; a few of them, however, are long vibrios.	Life is present to about the same extent, and with the same vitality, as exists in 1.	Same class of vibrios exist here as in 1 and 2, and to about the same extent and with the same amount of vitality. So that up to this point there appears to be little or no difference in the amount of life.	There is a very decided decrease in the amount of life here. All the long and nearly all the ordinary vibrios have been destroyed. Two or three small vibrios are still present, moving to and fro under each field.	The presence of life was doubtful.	No life present. The albumen on the glass-slip has been charred, and pieces of the charred mass appear under the microscope to resemble shellac.	No life present. The albumen on the slip is charred to a greater extent than 6, while small carbonised pieces were mixed with those resembling shellac.

Series II.—Slips (*dried in bath for fourteen hours between* 212° *and* 220° *F.*) were then heated at the various temperatures. Moistened with water on the slide of the microscope, and examined immediately afterwards.

Dried in bath, but not heated after.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1.	2.	3.	4.	5.	6.	7.
There are seven or eight animalculæ under each field. They are principally ordinary vibrios, a few long and very long vibrios are present.	Exactly the same class of life is present as in 1. It exists to the same extent, and with the same amount of vitality.	There is no difference in the life present to that existing in 1 or 2.	There is a very decided decrease of life to that observed in 1, 2, or 3. All the ordinary, long, and very long vibrios have been destroyed, and only a few small black ones are left, which are sufficiently distinct in their appearance and motion to show that they are still alive.	The presence of life was doubtful.	No life present.	No life present.

Series III.—Slips (*dried in the air*), and afterwards having been heated to the different temperatures, were introduced into small tubes containing pure distilled water on the 11th of July, hermetically sealed, and on the 15th of July the water in each of the tubes was examined.

Water alone for comparison.	Not heated at all.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1. No animalculæ life present.	2. Four or five ordinary vibrios are present in the whole drop, two or three of which are swimming.	3. Forty *bacteria* and vibrios are sprinkled about under each field and 10 or 12 long and ordinary vibrios are swimming.	4. One or two large or ordinary vibrios are observed under most of the field moving to and fro.	5. A few energetic microerphymes and small vibrios are present. No *bacteria.*	6. No trace of animalculæ life is present, but a number of pieces of matter are oscillating to and fro.	7. No animalculæ life present.	8. No animalculæ life present.

Series IV.—The Slips (which had been *dried in bath at 212° and 220° F.*), were afterwards heated to the different temperatures, and the slips then taken from their original tubes were introduced on the 11th of July into tubes containing pure distilled water, and examined on the 15th.

Merely dried in bath, not heated.	Heated to 100° F,	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1. About one ordinary vibrio was observed moving to and fro under each field.	2. The appearance of this fluid is exactly the same as No. 1.	3. About seven or eight *bacteria* are present under each field, and one ordinary swimming vibrio is present under most of the fields.	4. One or two ordinary swimming vibrios were observed in the whole drop of liquid employed.	5. No animalculæ life present.	6. No animalculæ life present.	7. No animalculæ life present.

Series V.—The Slips (which had been *dried at natural temperature*), were afterwards heated to the different temperatures, and then introduced into tubes containing equal quantities of an albumen solution. They were then hermetically sealed on the 11th of July, and examined on the 15th.

Albumen alone for comparison.	Not heated at all.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1. No distinct vibrio life is present.	2. Four or five vibrios were observed moving to and fro throughout. No *bacteria* were observed.	3. Four or five *bacteria* and vibrios were present, and one or two long vibrios were swimming.	4. One or two ordinary vibrios moving to and fro, and one or two *bacteria* were observed, but no swimming life was present.	5. A few *bacteria* were present throughout the field, and a very few were moving to and fro.	6. No life.	7. No life.	8. No life.

Series VI.—Examination of the water solutions into which had been dipped the slips of glass (*dried in bath between the temperature of 100° and 120° F.*) previously to being heated to the different temperatures. The slips were then introduced into tubes containing an albumen solution, were sealed on the 11th of July, and examined on the 15th.

Albumen alone for comparison.	Not heated at all.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1. No distinct vibrio life present.	2. About ten or twelve ordinary *bacteria* and vibrios are present and twelve or fourteen ordinary vibrios are swimming. There are also some fungi, which give the fluid a turbid appearance when shaken up.	3. There is nearly the same amount of life, and the fluid has much the same appearance as in No. 2.	4. Life is present, but not to the extent as it exists in Nos. 2 or 3.	5. A few *bacteria* and vibrios are present and one or two ordinary vibrios and microerphymes are swimming.	6. No life.	7. No life.	8. No life.

ON THE ACTION OF HEAT ON PROTOPLASMIC LIFE DRIED ON COTTON FABRICS.

The papers which I have previously published on the action of heat on animalculæ life having been almost entirely of a purely scientific character, I propose in this to give a series of experiments which have a direct bearing on the question of the disinfection of fabrics and wearing apparel by the use of heated stoves, with the object of destroying animalculæ life, and, possibly, contagion.

To carry out these views, a piece of ordinary grey calico was treated chemically, and washed until free from all sizing material, and dried; this prepared cloth was then steeped in a solution of putrid albumen containing abundance of animalculæ life, wrung out, and dried at the natural temperature. It was cut into small pieces, 5 centimetres square, and each of the pieces was folded in two, rolled up, and introduced into a small strong glass tube of 6 centimetres in length and 9 millimetres in diameter; each tube was then hermetically sealed at the blowpipe.

These specimens of calico were prepared on the 8th of August, and on the 9th thirty-five small pieces were sealed in tubes. On the 10th, five of the tubes were set aside, and the remaining thirty were placed in an oil-bath and gradually heated up to 100° F., and kept at that temperature for half-an-hour. Five of the tubes were then taken out, and the temperature raised successively to 200°, 300°, 400°, 500°, and 600° F., kept at each temperature half-an-hour—five tubes being taken out at the end of each half-hour.

On the following day, one of the tubes which had been heated at each determined temperature, was opened, the cloth placed in a small quantity of water, and a quarter of an hour afterwards some of the solution so obtained was examined under the microscope, and the facts observed are specified on Table I. (page 31.)

On the 14th of August, one of the small tubes from each series was broken, and the heated cloth introduced into seven tubes, each containing 400 grains of pure distilled water free from life, and left for three days to ascertain if the life which had resisted 200° and 300° F. was still capable of reproduction, and if the germs, as well as the animalculæ, had been destroyed by a temperature of 400°, 500°, and 600°. See Table II. for results, page 32.

A second series was made by introducing similar pieces of cloth (which had been also heated to the different temperatures already stated) into tubes containing an albumen solution, made by mixing one part of white of egg with four of absolutely pure distilled water, free from any trace of life, and these set aside for the same length of time to corroborate the above results, and the different fluids of this series were microscopically examined on the 17th of August, and Table III. shows the results, page 33.

From an examination of table I., it will be seen that life was *not* destroyed in the fabric at a temperature of 300° F., whilst *it was* destroyed at 400°, and that these results coincide with those obtained when microscopic life was submitted to heat in the fluids in which it had been generated, but differ from those observed in the experiments described in my last paper, where a fluid full of microscopic life was placed on slips of glass dried carefully, either at natural temperatures or in an air-bath at 212°, previously to being heated in the oil-bath at higher temperatures, when animalculæ life was only destroyed after 400°; these results are no doubt due to the albuminous nature of the protoplasmic life existing under these circumstances. These facts are in accordance with results obtained by my learned master, M. Chevreul, forty years since—namely, that it requires a much higher temperature to coagulate albumen when once deprived of its water than when it is in its natural state, as in an egg, and all chemists know that the coagulating-point of an albuminous solution bears a certain ratio to its degree of concentration, namely, the more it is diluted the higher the temperature required. The only explanation I can offer for the destruction of life at 300° in dried calico, is that the fabric having been, as will be seen further on, softened at 300°, has undergone a certain amount of decomposition, a part of its elements have united together to produce water, which, becoming high-pressure steam at the temperature at which I operated, has coagulated the albumen, which enters into the composition of vibrios, etc.

It will also be remarked that the amount of life in the cloth heated to 300° is similar to that on the plates of glass—viz., that in both instances it is much more abundant than when such animalcules were heated in the fluids in which they had been generated, which illustrates the fact that the larger the proportion of fluid which exists in the animal itself, the lower is the temperature at which life is destroyed.

As it was interesting to know what changes the calico had undergone at the various temperatures above cited, one of each of the small tubes which had been heated to the different temperatures was broken, and its contents carefully examined. The piece of fabric which had not been heated at all and those which had been heated to 100° and 200° F. were quite sound; whilst that heated to 300° was of a slightly brown colour, much injured, and for all practical purposes completely spoiled. At 400° F. the cloth was very much charred, almost black, and crumbled easily into powder when rubbed between the fingers; and the tubes contained a large volume of gases, which escaped when it was open, owing to the destruction of the cloth. At 500° F. the cloth had been completely carbonised, and the tube contained also much gas. At 600° F. the cloth was completely converted into charcoal, and various hydrocarbon gases generated.

The above results satisfactorily demonstrate that germ life existing in a fabric is not completely destroyed at 300° F., whilst it is at 400°. These results not only confirm those previously obtained, but establish the fact that *a temperature which will not destroy germ life is quite sufficient to materially injure cotton fabric.* From these carefully conducted experiments, I am led to the conclusion that no beneficial results can be obtained by the employment of public stoves as a means of destroying germ life and probably contagion.

TABLE I.—Results of the examination of the water solution into which the fabrics had been dipped immediately after they had been subjected to the various temperatures.

Water used for experiment.	Cloth not heated.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1 No vibrios nor *bacteria*.	2. A considerable quantity of vibrios are present moving to and fro, but no swimming vibrios.	3. About the same quantity of life as in 2, and having about the same amount of vitality.	4. There are fewer vibrios present than in 2 or 3, but a large quantity still exists, and they possess about the same vitality as in columns 2 or 3.	5. Considerably less life than in 4, but several distinct vibrios are present in each field moving to and fro.	6. No life.	7. No life.	8. No life.

Table II.—*Water Series.*—Examinations of the fluids into which some of the heated fabrics had been introduced on the 14th August, 1871; examined microscopically on August 17th.

Water alone for comparison.	Cloth. Not heated.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1.	2	3.	4.	5	6	7.	8.
No vibrios nor *bacteria*.	The whole of each of the fields of the microscope is covered with long, ordinary, and small-sized *bacteria*. Three or four ordinary, long, and small vibrios are swimming in each field.	Thirty to forty long *bacteria*, and three or four long swimming vibrios are present in each field.	Forty or fifty long, ordinary, and small *bacteria* are present under some of the fields, and very large shoals of *bacteria* under others. One or two long vibrios are swimming about.	The lower part of each field is covered with ordinary, long, and small *bacteria*. And a considerable number of long vibrios are present.	No *bacteria* and no vibrios present.	No *bacteria* and no vibrios present.	No *bacteria* and no vibrios present.

Table III.—*Albumen Series.*—Examination of the albuminous solutions into which had been introduced the heated fabrics on the 14th August, 1871, and examined on August 17th.

Albumen solution alone for comparison.	Cloth. Not heated.	Heated to 100° F.	Heated to 200° F.	Heated to 300° F.	Heated to 400° F.	Heated to 500° F.	Heated to 600° F.
1.	2.	3.	4.	5.	6.	7.	8.
No vibrios present.	Twenty to thirty ordinary vibrios and microzyma, and a small number of long vibrios are swimming about in all directions.	Nine or ten ordinary swimming vibrios, and four or five long vibrios are moving to and fro in each field.	About the same amount of life is present here as was observed in No. 3.	Four or five long swimming vibrios, and some vibrios joined together float in each field.	No vibrios present.	No vibrios present.	No vibrios present.

ON THE RELATIVE POWER OF THIRTY-FOUR SUBSTANCES TO PREVENT THE DEVELOPMENT OF PROTOPLASMIC AND FUNGUS LIFE.

To carry out this series of experiments, test-tubes having a length of about fifteen centimetres and a diameter of one and a half centimetres, were rinsed with hot vitriol, washed thoroughly with water, and heated to dull redness.

Into each of the tubes was introduced ·026 grammes of one of the substances, the action of which I desired to study. To it was added 26 grammes of a solution of albumen, containing one part of white of egg in four parts of *pure distilled water*, prepared as described in my paper on protoplasmic life.

The reasons why I employed one part of substance in a thousand parts of fluid are two-fold. First, the employment of larger proportions of substance would, in some instances, have coagulated the albumen. In the second place, it would have increased the difficulty of observing the relative powers of the most efficacious antiseptics in preventing the development of the germs of putrefaction or decay.

In order the more thoroughly to mix the substances in the tubes, a small glass stirring rod was heated to redness and suspended by a copper wire at the open end of each tube, so as to allow the end of the rod to remain constantly in the liquid.

After having stirred the mixture together in each of the tubes, a drop was taken and examined under a microscope having a magnifying power of eight hundred diameters, and this operation was repeated with the contents of each tube for thirty-nine consecutive days, during which time the tubes were kept in a room, the temperature of which did not vary more than three degrees, namely, from 12.5° to 15.5° C.

I shall now proceed to describe the antiseptic power of the various substances which I have employed, and which I have divided into classes, so as to shew in a more marked manner the relative action of substances having a similar chemical composition. Thus I have grouped together the acids into one class, the alkalies into another, and so on, with the chlorine compounds, the sulphates and sulphites, etc., etc.

In order the better to illustrate the influence of the antiseptics used, I examined two solutions of albumen, one of which was kept in the laboratory, the other in the open air. These solutions may be considered as standards of comparison.

Standard Solutions.

Substances taken.	Number of days required for development of life.	Time after which putrid odour could be detected.	Number of days required for development of fungus life.	Number of days after which mouldy odour could be detected
Albumen solution kept in laboratory.	12	50	18	None
Albumen solution outside laboratory	5	19	None	None

The results shew that the albumen solution which was exposed outside the laboratory became impregnated with animal life in less than half the time required by that kept in the laboratory. This, I believe, is due to the more frequent change of the mass of air inside the tube, thereby introducing a larger number of germs.

It was also observed that the vibrios developed themselves with greater rapidity in the tube outside than in the one inside the laboratory, so much so that there were as many vibrios in six days in the former as in thirty days in the latter.

Many of my observations already tend to shew that in a fluid mass where there is a great amount of vibrio life, fungi do not make their appearance, and this is probably the reason why, no fungus life appeared in the albumen solution exposed outside the laboratory.

Class 1.—*Acids.*

This class is represented by :—1. Sulphurous. 2. Sulphuric. 3. Nitric. 4. Arsenious. 5. Acetic. 6. Prussic Acids.

Substances taken.	Number of days required for development of vibrio life.	Number of days afterwhich putrid odour could be detected.	Number of days required for development of fungus life.	Number of days required before mouldy odour could be detected
1. Sulphurous acid.	11		21	
2. Sulphuric acid.	9		9	11
3. Nitric acid.	10	50	10	23
4. Arsenious acid.	22		18	50
5. Acetic acid	30		9	50
6. Prussic acid	9	23	No fungus life appeared.	

Sulphuric, nitric, and acetic acids produced slight precipitates with the albumen solution, whilst the other three acids did not.

The mouldy odour perceptible in sulphuric acid after 11 days, had entirely disappeared after 50 days.

Sulphurous acid was the only one of this series which gave off no odour during the whole time the experiments were conducted.

It is interesting to observe that acids do not prevent the appearance of either protoplasmic or fungus life; in fact, they rather promote the growth of fungi, and in two instances, those of sulphuric and acetic acids, this growth was so abundant that after three or four weeks the entire surface of the fluid was covered with a thick mass, which in the case of sulphuric obtained the height of above a centimetre.

I have already mentioned that when fungus life becomes abundant, and covers the surface of a fluid, vibrio life gradually disappears, and at last becomes extinct.

Acids also appear to prevent the phenomena of putrefaction, but the results obtained cannot be considered decisive, the temperature at which the experiments were conducted not being that most favourable to the promotion of putrefaction. But I have made a special series of experiments on this point which I have noticed further on.

Class 2.—Alkalies and Alkaline Earths.

1. Caustic Soda. 2. Ammonia. 3. Potash. 4. Hydrate of Lime.

Substance taken.	Number of days required for development of vibrio life.	Time after which putrid odour could be detected.	Number of days required for development of fungus life.	Number of days required before mouldy odour could be detected
1. Soda.	23	31	18	29
2. Potash.	16			
3. Ammonia.	24	50	20	None
4. Lime.	13	19	None	None

The alkalies, and especially lime, promote the development of vibrio life, and greatly facilitate the phenomena of putrefaction, and with the exception of lime, do not prevent the production of fungi.

Class 3.—Chlorine and its Compounds.

1. Solution of chlorine. 2. Chloride of Sodium. 3. Chloride of Calcium. 4. Chloride of Aluminium. 5. Chloride of Zinc.

6. Bichloride of Mercury. 7. Bleaching Powder. 8. Chlorate of Potash.

Substances employed.	Number of days required for development of life.	Time after which putrid odour could be detected.	Number of days required for development of fungus life.	Number of days when mouldy odour could be detected.
1. Solution of chlorine.	7	21	21	
2. Chloride of sodium.	14	50	50	
3. Chloride of calcium.	7	None	18	50
4. Chloride of aluminium.	10	None	21	50
5. Chloride of zinc.	None	None	50	None
6. Bichloride of mercury.	None	None	81	None
7. Bleaching powder.	7	18	16	
8. Chlorate of potash.	17	None	19	None

The results obtained with the above eight compounds are most interesting and instructive, and in several instances are quite different to those which might have been anticipated.

Thus it will be observed that only two of the chlorides prevent the appearance of protoplasmic life, and that none, not even bichloride of mercury, entirely prevent fungus life, although in the latter case it required eighty-one days for its development.

Again, when chlorine or bleaching powder are employed in the small proportion above stated, they do not prevent the production of vibrio life. It might be objected that the quantity employed is small, but that objection does not stand good, because other substances used in the same proportion exercise a far greater action than these two supposed powerful antiseptics. To ascertain its action in larger quantities, the following experiments were made:—

First, a pure solution of albumen was taken.

Secondly, the same solution, to which was added one per cent. of chloride of lime.

Thirdly, to this solution five per cent. of chloride of lime was added.

The experiments were commenced on the 12th March, 1872, and kept at a constant temperature of 80° Fahr. for several days.

No. 1. Pure solution of albumen. *After 4 days* two or three vibrios were present, moving to and fro under each field of the microscope.

After 14 *days* the fluid had become as clear as pure water, and microscopic life was rather abundant.

After 17 *days* fungi had made their appearance on the surface, and only a small quantity of microscopic life was observed.

After 22 *days* there was a thick growth of "pennicellium glancum" on the face of the fluid; it emitted a mouldy odour, and a few vibrios were moving to and fro under each field of the microscope.

No. 3. Five per cent hypochlorite of lime.

After 4 *days* a distinct smell of chlorine was still noticed, although the albumen had undergone decomposition, gases being given off.

After 14 *days* only one or two vibrios were observed throughout each drop; it emitted an odour of a peculiar chlorine compound. The fluid had a brownish yellow colour, and a dense precipitate at the bottom.

After 17 *days* no fungi were present; it emitted a faint odour (not putrid), and contained little or no vibrio life.

After 22 *days* it emitted still the peculiar odour before noticed, mixed with a very faint putrid one; a number of microzymes and three or four vibrios were observed moving under each field.

I have further ascertained by a long series of experiments that when 5 per cent. or larger quantities of bleaching powder are put in contact with any animal substance such as albumen, fibrin, wool, &c., a part of their carbon is converted into carbonic acid, whilst a certain portion of the nitrogen is liberated in a free state.

I may further add that when large quantities of bleaching powder have been used, but not in excess, all protein substances will still after a time enter into putrefaction.

Extraordinary as this statement may appear, I am happy to be able to confirm it by the observation of a savant who has had great experience in its use, namely, M. Devergie, General Inspector of the Cemeteries of France, and Director of the Morgue at Paris. He says that corpses decay more rapidly if placed in contact with bleaching powder, or a solution of it, than if water alone is employed.

The above facts shew that bleaching powder is of no value as a preventive of decay or putrefaction, and that the theory that it has such an affinity for the hydrogen of germs as to destroy them, is erroneous; as hypochlorite of lime does not act on the hydrogen of animalcules and organic substances as above stated, but on their carbon and nitrogen.

Class 4.—Sulphur Compounds.

1. Sulphate of Lime. 2. Sulphate of Protoxide of Iron. 3. Bisulphite of Lime. 4. Hyposulphite of Soda.

Substances taken.	Number of days required for development of vibrio life.	Time after which putrid odour could be detected.	Number of days required for development of fungus life.	Number of days after which mouldy odour could be detected
1. Sulphate of Lime.	9	24	19	None
2. Sulphate of Protoxide of Iron.	7	None	15	
3, Bisulphite of Lime.	11	21	14	None
4. Hyposulphite of Soda.	11	50	18	None

The results obtained with this series are very instructive and useful, especially with reference to sulphate of protoxide of iron and bisulphite of lime, which have been employed as antiseptics for many years.

We here see that they do not prevent the presence of either vibrio or fungus life, and if no putrid odour was perceived with sulphate of iron it was doubtless due to the sulphate of iron fixing the sulphuret of ammonium by the formation of sulphuret of iron and sulphate of ammonia.

It is probable, however, that if used in much larger quantities, these two compounds might have preserved the albumen for a longer period of time.

Class 5.—Compounds of Phosphoric Acid.

Phosphate of Soda and Phosphate of Lime, were taken.

Substances taken.	Number of days required for development of vibrio life.	Time after which putrid odour could be detected.	Number of days required for development of fungus life.	Number of days before mouldy odour could be detected.
1. Phosphate of Soda.	13	None	17	23
2. Phosphate of Lime.	7	26	22	None

Neither of these salts prevent the formation of vibrios or fungus life, but they present this peculiarity, that, while phosphate of lime does not prevent putrefaction, phosphate of soda does, and the reverse is the case as regards the development of the mouldy odour.

Class 6.—Compound acting by Oxidation only.

Permanganate of Potash.

Substance taken.	Number of days required for development of vibrio life.	Number of days before putrid odour could be detected.	Number of days required for development of fungus life.	Number of days before mouldy odour could be detected.
Permanganate of potash.	9	50	22	None

This salt does not prevent the formation of vibrios; in fact, life increased rapidly for several days, and then appeared to be comparatively stagnant. The most interesting facts concerning this salt are that at no time could a mouldy odour be perceived, and that fifty days elapsed before any putrid smell could be detected.

Class 7.

Carbolic and Cresylic Acids, and Turpentine.

Substances taken.	Number of days required for development of vibrio life.	Number of days before putrid odour could be detected.	Number of days required for development of fungus life.	Number of days before mouldy odour could be detected.
1. Carbolic acid.	None	None	None	None
2. Cresylic acid.	None	None	None	None
3. Turpentine	14	None	42	None

The first two products are the only ones of the thirty-four substances employed which entirely prevented the appearance of vibrio and fungus life, for eighty-one days, during which these experiments were conducted.

The employment of essential oils having been often recommended as a means of preventing putrefaction and decay, turpentine was taken as a representative of this class of substances.

It will be noticed that vibrios and fungi appeared after fourteen and forty-two days respectively, but in neither case did any disagreeable odour arise.

Class 8.—*Sulphocarbolates.*

Potash, Soda, and Zinc.

Substances taken.	Number of days required for development of vibrio life.	Number of days before putrid odour could be detected.	Number of days required for development of fungus life.	Number of days before mouldy odour could be detected.
1. Sulphocarbolate of potash.	16	33	17	21
2. Sulphocarbolate of soda.	18	50	19	25
3. Sulphocarbolate of zinc.	None	None	27	50

This class of salts having been much recommended of late as therapeutic agents, I deemed it advisable to compare them with other well known antiseptics.

From the table given above it will be observed that the salts of potash and soda present no very remarkable features, whilst that of zinc is a most powerful agent, and yields in none of its properties to chloride of zinc, except that fungus life appears after twenty-seven days instead of after fifty as in the case of the chloride.

Class 9.

Organic compounds used in medicine. 1. Sulphate of Quinine. 2. Picric Acid. 3. Pepper.

Substances taken.	Number of days required for development of vibrio life.	Number of days before putrid odour could be detected.	Number of days required for development of fungus life.	Number of days before mouldy odour could be detected.
1. Sulphate of quinine.	26	None	None	None
2. Picric acid.	17	None	19	65
3. Pepper.	8	None	None	None

The results given in this table are most interesting and instructive, for although none of these substances prevent the presence of animal life, still they (inert as they appear) prevent mouldiness and the odours of putrefaction.

This peculiar power of sulphate of quinine to arrest the production of fungus life deserves notice, especially when considered in connection with the remarkable efficacy which quinine exerts in cases of intermittent fever, and leads to the inference that this class of disease may be due to the introduction into the human system of fungus germs, which would locate themselves in the spleen and create fever, and this is rendered more probable if we consider that these fevers are prevalent only in low marshy situations where vegetable decay abounds, and never appear to any extent in dry climates, even in the midst of dense populations where ventilation is bad and putrefaction is rife.

The only substance now remaining to be noticed is charcoal. The results obtained were:

Substance taken.	Number of days required for development of vibrio life.	Number of days before putrid odour could be detected.	Number of days required for development of fungus life.	Number of days before mouldy odour could be detected.
Charcoal.	6	50	21	None

I was induced to employ this substance owing to its having been much used as a purifier.

The results above obtained clearly indicate that it has no antiseptic properties, and that, as shewn by the researches of Dr. Stenhouse and myself, it prevents the emanations of putrid odours and noxious gases by its extraordinary condensing power, due to its porosity, and thus brings them in contact with the oxygen of the atmosphere, which oxidizes them and converts their elements in inodorous compounds.

In comparing carefully the above general results, I am led to class the specific action of the thirty-four substances under four distinct heads, namely, those which prevent the development of protoplasmic and fungus life; those which arrest the production of vibrio life, but do not that of fungus life: those which permit the production of vibrio life, but prevent the appearance of fungus life; and those which allow the development of both protoplasmic or fungus life.

The first class is represented by only two substances, carbolic and cresylic acids.

In the second class there are also two substances, chloride of zinc and bichloride of mercury.

The third is composed of five substances, lime, sulphate of quinine, pepper, turpentine, and prussic acid.

The fourth class is represented by the remaining twenty-five substances.

It may also be interesting to note the state of the fluids after fifty days.

The albuminous solutions containing sulphurous acid, chlorate of potash, picric acid, pepper, and turpentine, allowed the growth of vibrio and fungus life, but did not emit any unpleasant odour.

The solutions which only emitted a mouldy smell, are those of arsenious and acetic acids, the chlorides of calcium and aluminium, sulphate of protoxide of iron, and phosphate of soda.

Those which gave off only a putrid odour are nitric and prussic acids, lime, soda, ammonia, bleaching powder, chlorine solution, chloride of sodium, sulphate of lime, bisulphite of lime, hyposulphite of soda, phosphate of lime, permanganate of potash, the sulphocarbolates of potash and soda, and charcoal.

Confidence may be placed in these results, as they corroborate a previous series of experiments commenced on March 17, and continued until the beginning of July.

Many of the facts cited in the foregoing pages were so unexpected that a series of experiments was made substituting gelatine for albumen. It was begun on the 17th of May, and lasted forty-seven days.

Without entering into minute details, an outline will be here given of some of the most marked differences observed between the gelatine and albumen solutions, thus—Vibrio life appeared in two days in gelatine solution, and bacteria after four or five; during the whole time which lasted these experiments, life was far more abundant in these solutions than in the albumen ones. A distinctly putrid smell was given off after twenty-six days.

The action of bleaching powder differed in this case from its action on albumen. It took twenty-six days for life to appear as compared with seven in the case of albumen, and at no period during the twenty-seven days following was life abundant. No putrid odour was at any time emitted, but a mouldy one could be detected after thirty days.

With chlorine solution vibrio life was only observed after forty days. No putrid or mouldy smell was given off at any time.

Protosulphate of iron gave results with this solution quite different from those with albumen, which it will be remembered allowed vibrios to appear after seven days, and fungi after fifteen. With gelatine, however, neither protoplasmic nor fungus life appeared during the forty-seven days.

Arsenious acid also presented a marked difference in its action on the two solutions. With albumen twenty-two days elapsed before vibrios were present and eighteen before fungi appeared, but in the gelatine animal life appeared after two days, while fungi could not at any time be found.

The action of the other substances on the two solutions were so nearly identical that it is unnecessary to describe them here.

I may state that Mr. Robert Hamilton, F.R.C.S., published in the *Lancet*, of November 11th and 18th last, a paper having some similarity with mine, but as I confined my attention to certain particular points, while he had other objects in view, the mode of conducting the experiments differed considerably. I therefore deem it unnecessary to notice any apparent differences that may exist between our results, leaving to other experimenters to repeat and decide.

On the Relative Power of Thirty-four Substances in Arresting Putrefaction, and the Development of Protoplasmic and Fungus Life.

These experiments were undertaken as complementary to those described in my previous paper, and consisted in adding to a solution of albumen, swarming with microscopic life, one thousandth part of each of the substances already enumerated, and examining the solutions immediately upon their addition, and also after one and sixteen days.

The solutions to be tested were placed in tubes similar to those described in my last paper. The experiments were begun on the 20th September, 1871, the temperature being from 15° to 18° C. during the time they were conducted.

Table 1. *Standard Albumen Solution.*

Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Life very abundant.	Little apparent difference.	Odour more intense and disagreeable, and great increase of life.	Still further increase in quantity of life, and odour very bad.

It will be observed that the amount of life and putrescence increased during the whole of the sixteen days that the experiments lasted.

Table 2.

Class 1.—*Acids.*

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Sulphuric Acid.	Locomotive power of animalcules destroyed.	Only a faint putrid odour, and a small amount of life.	Mycilium fungus appeared in rather considerable quantity. Fluid had faint putrid odour. Small amount of life.	Fluid clear as water. Mycilium present on surface of fluid. Mouldy but not putrid odour. Larger quantity of life.
Nitric Acid.	Locomotive power of animalcules much impaired.	Faint putrid odour. Small amount of life.	Large amount of life, but not so great as in standard.	Odour, turbidity of fluid, and amount of life greater than standard.
Arsenious Acid.	No change.	No difference.	Odour and amount of life greater than in standard.	Odour, turbidity, and amount of life equal to standard.
Solution of Sulphurous Acid.	No change in quantity of life, but power of locomotion injured.	Odour similar to standard. Power of locomotion regained.	Odour same as on first day, but life greater than in standard.	Equal to standard in all respects.
Acetic Acid.	Decrease of life.	Faint putrid odour, but quantity of life same as previous column.	Fluid clear. Still faint putrid smell. Mycilium fungus present, and small amount of animalcule life.	The growth of fungi has stopped. Turbidity greater than in standard. Odour about the same, and quantity of life greater.
Prussic Acid.	Animalcules deprived of power of motion.	Faint putrid odour. Animalcules lively.	Fluid clearer than standard, but odour not so bad, and quantity of life less.	Same as standard in all respects.

It will be noticed in reading the contents of the above table, that four of the Acids, Sulphuric, Nitric, Acetic, and Prussic, appear to have paralysed the locomotive power of microscopic life, whilst Arsenious and Sulphurous have produced no influence. After twenty-four hours life had reproduced itself in the four first-mentioned Acids. On the sixteenth day the difference is very marked and interesting, animal life having greatly increased in Nitric, Arsenious, Prussic, and Sulphurous Acids, but had made but small progress in Sulphuric and Acetic Acids, fungus life having appeared in these two latter Acids, and increased rapidly during the remaining ten days, and thereby, as previously stated, prevents the development of animal life. (See page 13.)

Table 3.

Class 2.—Alkalies.

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Soda.	Large proportion of animalcules injured.	Fluid more turbid and putrid than standard. Animalcules lively again. Quantity of life same as at first.	Odour and quantity of life greater than standard.	Odour, turbidity and quantity of life much greater than standard.
Potash.	The same as soda.	The same as above.	The same as above.	The same as above.
Ammonia.	No effect produced.	Fluid emitted a more offensive odour, and was more turbid than standard, and the animalcules had increased.	Fluid more turbid and offensive, life more abundant than in standard.	Exactly similar to standard.
Lime.	No difference.	Similar to standard.	Putrid odour more intense, and animalcule life greater than in standard.	Worse in every respect than standard.

Soda and potash at first impaired the power of motion of the animal life, still the alkalies, as well as lime, greatly facilitate the development of life. Ammonia had no action or influence whatever.

Table 4. *Class 3.—Chlorine Compounds.*

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Solution of Chlorine.	No change	All odour of chlorine has disappeared and putrid odour and life same as standard.	Odour more offensive and life greater than in standard.	Odour very bad and turbidity and life greater than in standard.
Chloride of Sodium. Chloride of Calcium.	....	The same as above.	Same as above.	Same as above.
Chloride of Zinc.	Dense white precipitate produced. Life seriously affected.	White precipitate had subsided and carried with it most of the animalcule life. Fluid still possessed a faint putrid smell.	No putrid odour. Very small amount of life.	No putrid odour until stirred when a faint odour could be perceived. Very small amount of life.
Bichloride of Mercury.	White precipitate produced Animalcule life much injured.	The white precipitate had carried down with it much life, but some still remained in the liquor, and it had a faint putrid odour.	Very faint putrid odour. Large quantity of life present.	Putrid odour very faint. Turbidity equal to standard.
Bleaching Powder.	Less life than in standard.	Little or no putrid odour.	Distinct putrid odour. Fluid not so turbid as standard, nor life quite so abundant.	Same as standard.
Chloride of Aluminium.	Same as standard	Putrid odour & amount of life not quite equal to standard.	Putrid odour not so bad as standard.	Equal to standard.
Chlorate of Potash.	Same as standard	Same as standard.	Odour not so bad, and life considerably less than standard.	Same as standard.

The above results show that immediately after the addition of the above solutions to putrid albumen, the chlorine solution had no action, bleaching powder but a slight one, and only chloride of zinc, and bichloride of mercury, especially the latter, affected germ life. After twenty-four hours all odour of chlorine had disappeared from the solution, but that the putrid odour and amount of life had not decreased. With bleaching powder little or no putrid odour remained.

With chlorides of zinc and mercury the greater part of life had disappeared, only a slight putrid odour remained, and this continued for the whole of the sixteen days (this fact distinguishing them from the rest of the class), whilst the chlorides of sodium, calcium and aluminium, and chlorate of potash gave off an odour as intense as the standard. On the sixteenth day the chlorine and bleaching powder solutions had become putrid, and the amount of life was equal to the standard. I consider this latter result to be as interesting and remarkable as those to which I called attention in my first paper, as they confirm the fact that the powerful antiseptic and disinfecting powers which have been ascribed to them, do not exist, and I have come to the conclusion that they are merely deodorisers, and that only when employed in large proportion, as compared with the amount of organic matter to be acted upon.

Table 5. *Class 4.—Sulphur Compounds.*

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Sulphate of Lime.	No action.	No change.	No change.	
Sulphate of Iron.	Life very slightly decreased.	Odour and life are less: The presence of sulphuret of iron was distinctly visible.	Did not appear to have changed during the six days.	Putrid odour same as in standard, quantity of life rather greater. A large amount of sulphuret of iron had been produced.
Hyposulphite of Soda.	Equal to standard.	Equal to standard.	Odour more repulsive, and quantity of life greater than standard.	Putrid odour, turbidity and life equal to standard. Trace of sulphuretted hydrogen liberated.
Bisulphite of Lime.	Equal to standard.	Similar in all respects to standard.		

This class is interesting, two of the substances having been largely employed by medical men, namely, sulphate of protoxide of iron and bisulphite of lime, as the above results clearly show that this iron salt, like chlorine and bleaching powder, is a mere deodoriser and not an antiseptic, while bisulphite of lime employed in the above proportion possesses neither antiseptic nor deodorising properties; but probably, if employed in larger proportions, the compounds would doubtless be found to possess a certain antiseptic power.

Table 6.

Class 5.—Phosphate Compounds.

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Phosphate of Soda.	Same as standard.	Same as standard.	Odour and life more abundant than in standard.	Odour and turbidity nearly equal to standard, but quantity of life greater.
Phosphate of Lime.	Similar to standard.	Life apparently equal to standard, but odour more disagreeable.	Similar to standard.	Similar to standard.

This class calls for no remark.

Table 7.

Class 6.—Permanganate of Potash.

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Permanganate of Potash.	Part of permanganate decomposed Amount of life equal to standard.	No putrid odour. Life equal to standard.	Slightly putrid odour. Life rather more abundant than in standard. All permanganate decomposed.	Equal to standard. All permanganate decomposed.

On the admixture of the highly-coloured solution of salt with putrid albumen it was partly discoloured, but the amount of life did not appear decreased. After twenty-four hours all odour had disappeared, but after sixteen days the fluid was as full of life and had an odour as strongly putrid as the standard. These facts tend to prove that this salt is a deodoriser by oxidation, but not an antiseptic.

Table 8. *Class 7.—Tar Series.*

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Carbolic Acid.	Animalcule life very much injured.	Faint putrid odour. Amount of life very small.	No putrid odour. Amount of life still very small.	Same as six days.
Cresylic Acid.	Life very much injured.	No putrid odour. Life almost destroyed.	No putrid odour. Life almost destroyed.	Same as six days.
Turpentine.	Same as standard.	Same as standard.	Identical to standard.	

Although carbolic and cresylic acids prevent the production of vibrio life for any length of time, still they do not completely destroy it when once it has existed. The only class of life, however, which remains, is a small black or opaque vibrio, the same and the only one which can resist a temperature of above 300° C.; no change occurred during the sixteen days. Cresylic acid appears to be slightly more antiseptic than carbolic acid, as all putrid odour disappeared from the liquid. On comparing these results with those recorded in the previous paper, there can be no doubt but that these two bodies possess antiseptic properties of a high degree.

Although turpentine prevents, as we have already shewn, the development of life for a certain period, still it does not appear to affect that life when once formed.

Table 9.

Class 8.—Sulphocarbolates.

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Sulphocarbolate of Soda.	Animalcule life appeared to be injured.	Putrid odour and turbidity greater than in standard, and animalcules had recovered their vitality	Similar to standard.	Similar to standard.
Sulphocarbolate of Potash.	Animalcule are not so much injured as with soda salt.	Similar to above.	Similar to standard.	Similar to standard.
Sulphocarbolate of Zinc:	Animalcules nearly all destroyed.	Only faint putrid odour. In other respects equal to previous column.	Very faint putrid odour. Very small amount of life.	Very faint putrid odour. Very small amount of life.

The only salt which appears to act actively on microscopic life is that of zinc, and also is the only one of the series which prevents the development of protoplasmic life and putrefaction. As this compound is inodorous its employment deserves, I believe, the serious attention of medical practitioners.

Table 10.

Class 9.

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days
Sulphate of Quinine.	Power of locomotion of animalcules almost destroyed.	Slight putrid odour. Power of locomotion not entirely recovered	Faint putrid odour. Large quantity of life.	Faint putrid odour. Large quantity of life.
Picric Acid.	The same as above.	Slight putrid odour. Locomotive power partially regained.	Equal to standard	Equal to standard.
Pepper.	Same as standard.	Similar to standard.	Same as standard.	Identical to standard.

It is very instructive to compare the results obtained with these substances with those obtained with the same class of compounds in our previous paper. Sulphate of quinine and picric acid on being added to the putrid albumen solution, appear to deprive in a marked manner the vibrios of their power of locomotion, but after twenty-four hours they partially recovered their vitality, and after sixteen days, little difference exists between the standard solution and the above, thus showing that these substances, as well as pepper, have little or no action on germ life once developed.

Table 11. *Class* 10.—*Charcoal.*

Name of Substance.	Examination immediately after mixing.	Examination after one day.	Examination after six days.	Examination after sixteen days.
Charcoal.	Equal to standard.	Less odour than in standard, but more animalcule life.	Less odour than in standard, but more animalcule life.	Less odour than in standard, but more animalcule life.

It will be observed, in looking over this table, that the results correspond with those described in the previous paper, that carbon does not act on vibrio life, and that its properties are merely those of a deodoriser.

Some of the results recorded in this paper were so contrary to the generally received opinion as to the power of the substances to arrest decay, that I repeated them. I therefore made second trials with the following substances, viz.: chlorine solution, bleaching powder, sulphurous acid, bisulphite of lime, and protosulphate of iron, but the results were in every case in accordance with those herein described.

It is a remarkable fact that it is easier to prevent life from appearing in a fluid highly favourable to its production, than to destroy it entirely when once developed. I have in no instance succeeded in destroying it in the latter case, whilst in several instances it was prevented in the former.

ON THE RELATIVE POWERS OF VARIOUS SUBSTANCES TO PREVENT PUTREFACTION.

The two series of experiments above described suggested to me a third, namely, the time which would elapse before a solution of albumen when kept at a temperature of between 70° and 80° F. would acquire a distinct putrid smell, and also the time necessary for sulphuretted hydrogen and ammonia to be given off.

The following table gives a *resumé* of the results obtained during the eighty days which tho solutions were examined.

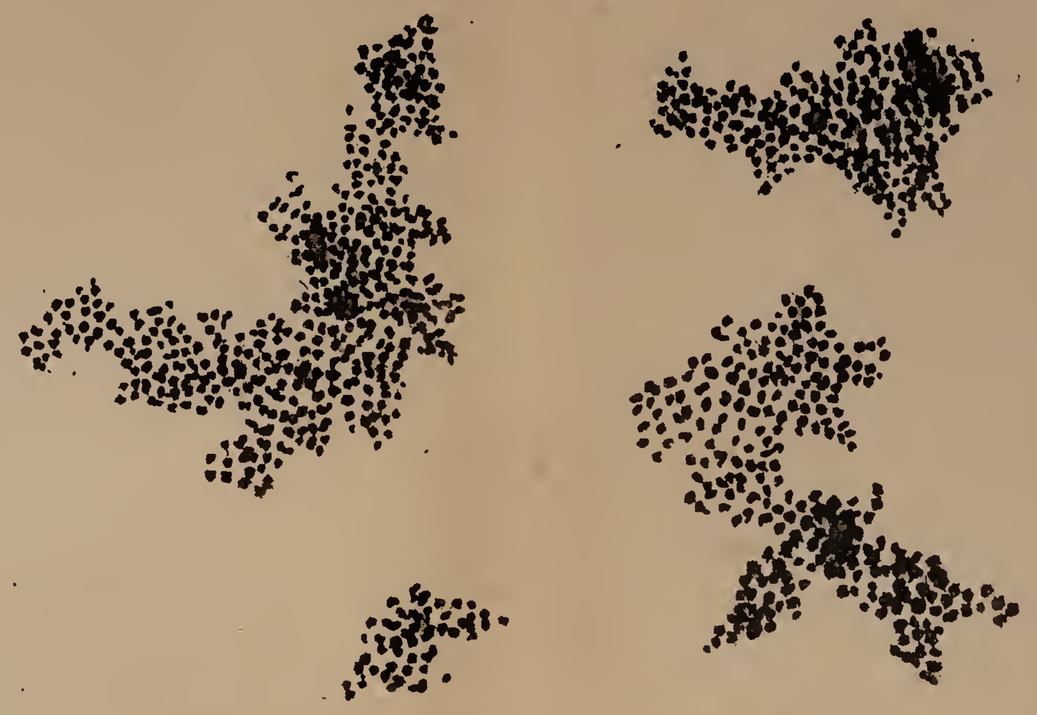
Time required for Development of Putrid Odours in Albumen Solutions kept at 80° F.

1. Standard Solution.	
Albumen kept in laboratory for comparison.	16 days.
2. Acids.	
Sulphurous acid.	45 „
Sulphuric acid.	16 „
Nitric acid.	16 „
Arsenious acid.	None
Acetic acid.	None
Prussic acid.	35 „
3. Alkalies.	
Caustic soda.	72 „
Caustic ammonia.	26 „
Caustic lime.	14 „
4. Chlorine Compounds.	
Solution of chlorine.	16 „
Chloride of sodium.	16 „
Chloride of calcium.	11 „
Chloride of aluminium	16 „
Chloride of zinc.	38 „
Bichloride of mercury	None
Chloride of lime	9 „
Chlorate of Potash	38 „
5. Sulphur Compounds.	
Sulphate of lime.	14 days.
Protosulphate of iron	16 „
Bisulphite of lime.	16 „
Hyposulphite of soda	11 „
6. Phosphates.	
Phosphate of soda.	16 „
Phosphate of lime.	16 „
7. Permanganate of potash	11 „
8. Tar Series.	
Carbolic acid.	None
Cresylic acid.	None
9. Sulphocarbolates.	
Sulphocarbolate of potash.	35 „
Sulphocarbolate of soda.	26 „
Sulphocarbolate of zinc.	None
10. Sulphate of quinine.	None
Picric acid.	26 „
Pepper.	16 „
Turpentine	35 „
11. Charcoal.	

These results show that out of the thirty-four substances which I employed only six prevented putrefaction. From the previous experiments it is not surprising that carbolic and cresylic acids, bichloride of mercury, and the salts of zinc should prevent putrefaction, but it is certainly very remarkable that sulphate of quinine should possess that property to such a high degree.

The results here described confirm in a general way those given in the first of this series of papers. (See pages 34 to 44.)

I cannot conclude these papers without expressing my sincere thanks to my assistant, Mr. William Thomson, for his valuable and intelligent help in these long and tedious investigations.

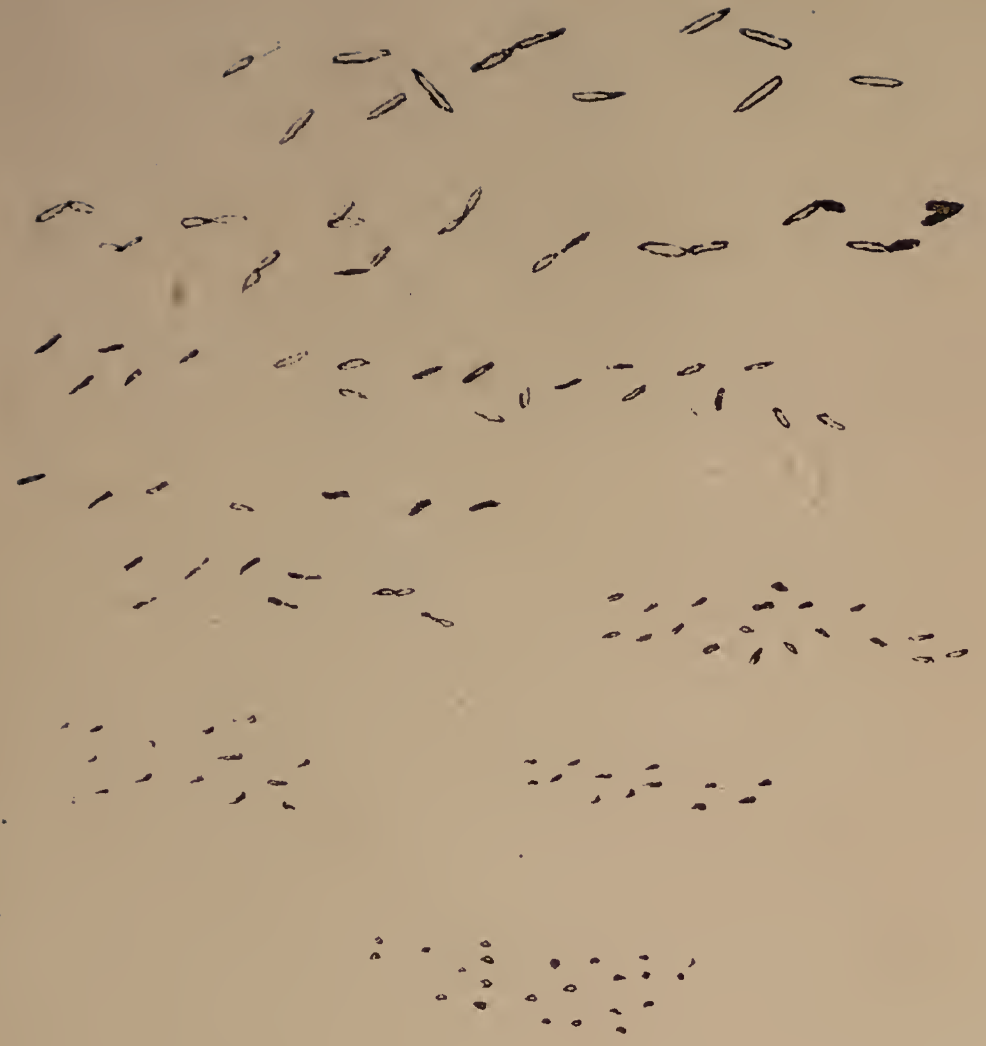


4

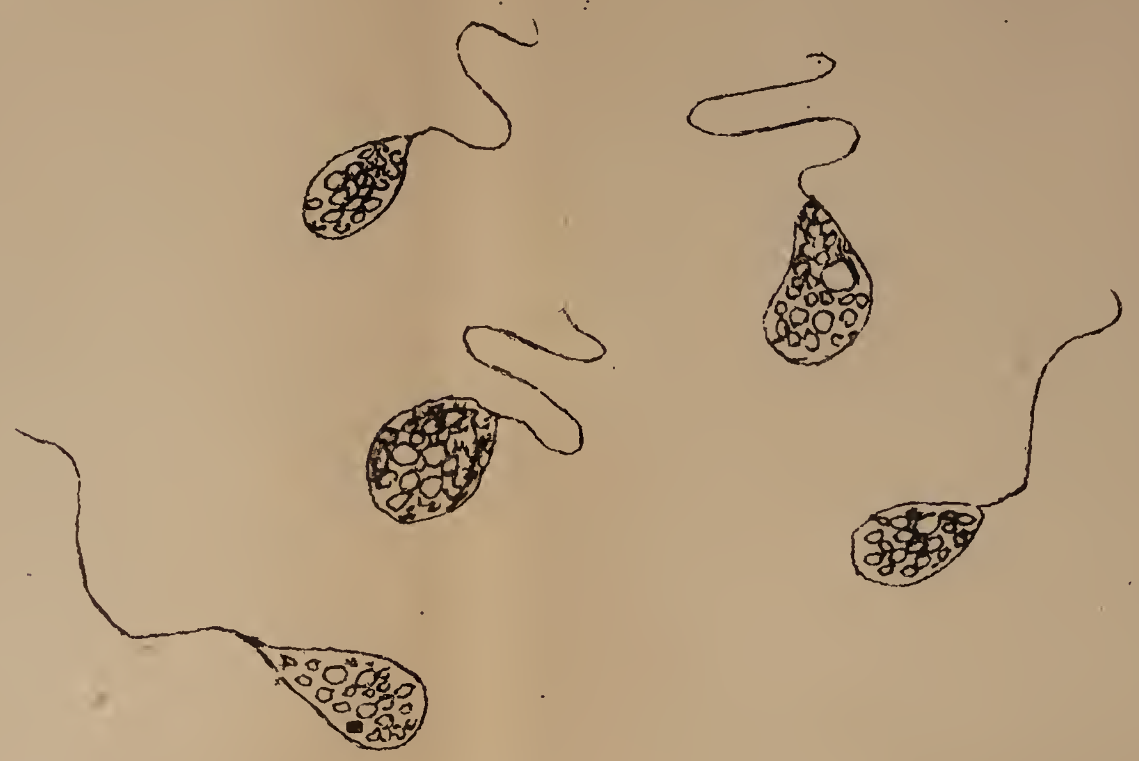
5

6

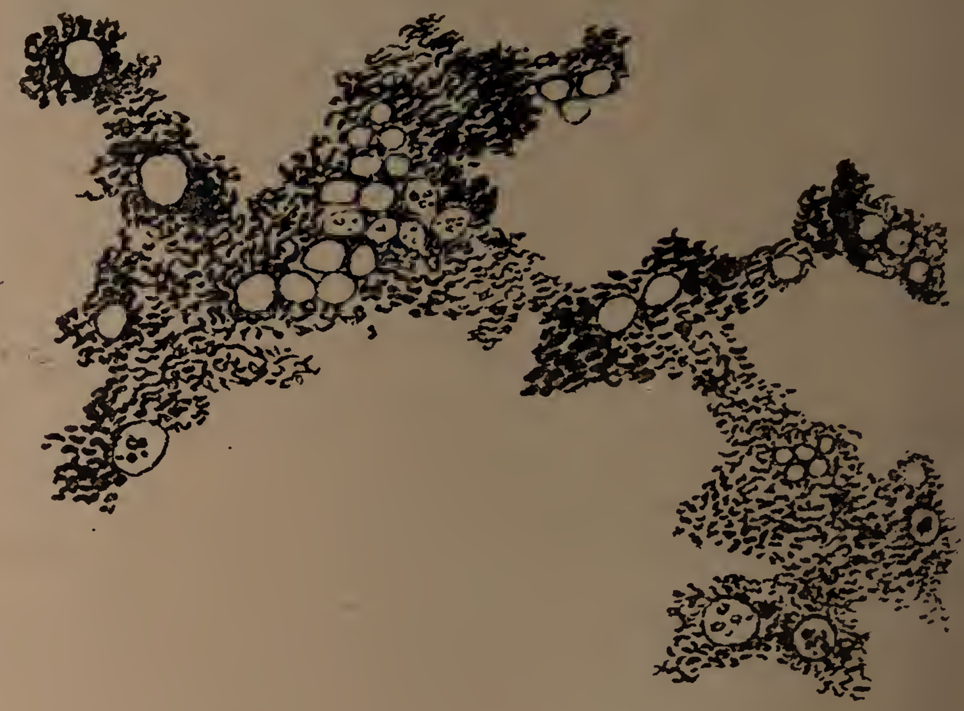
7



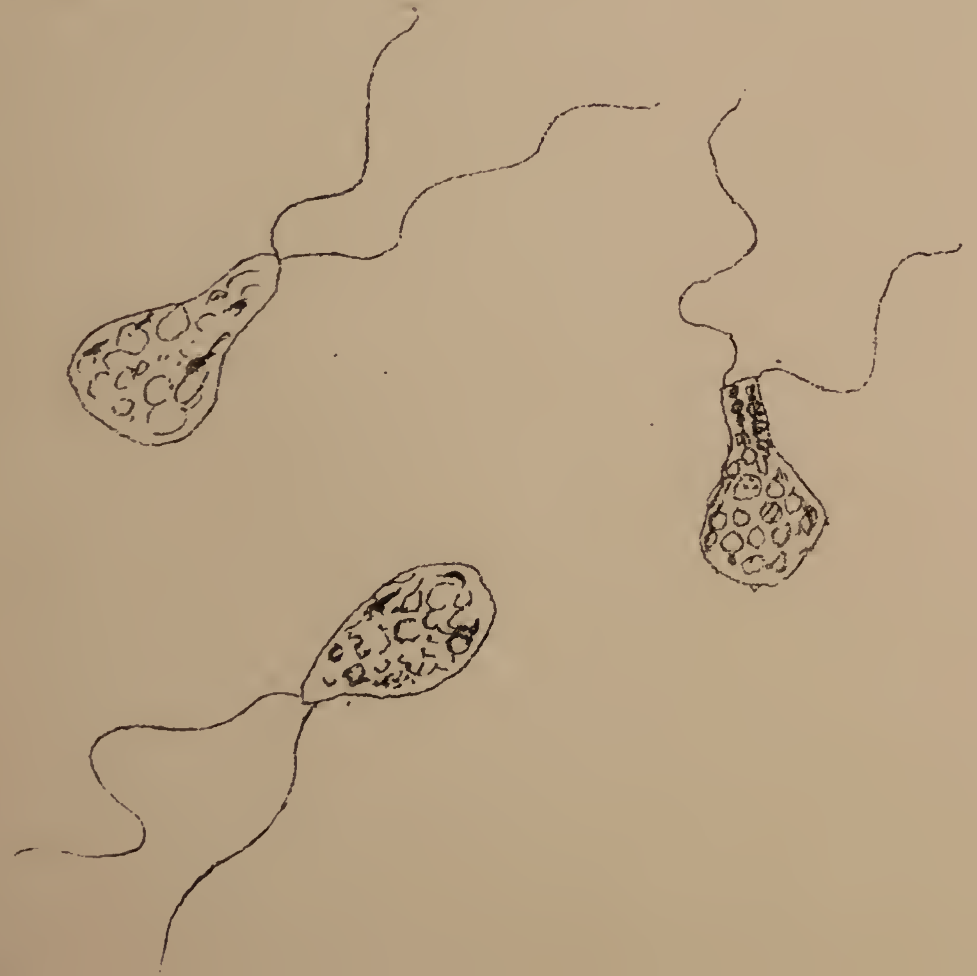
8



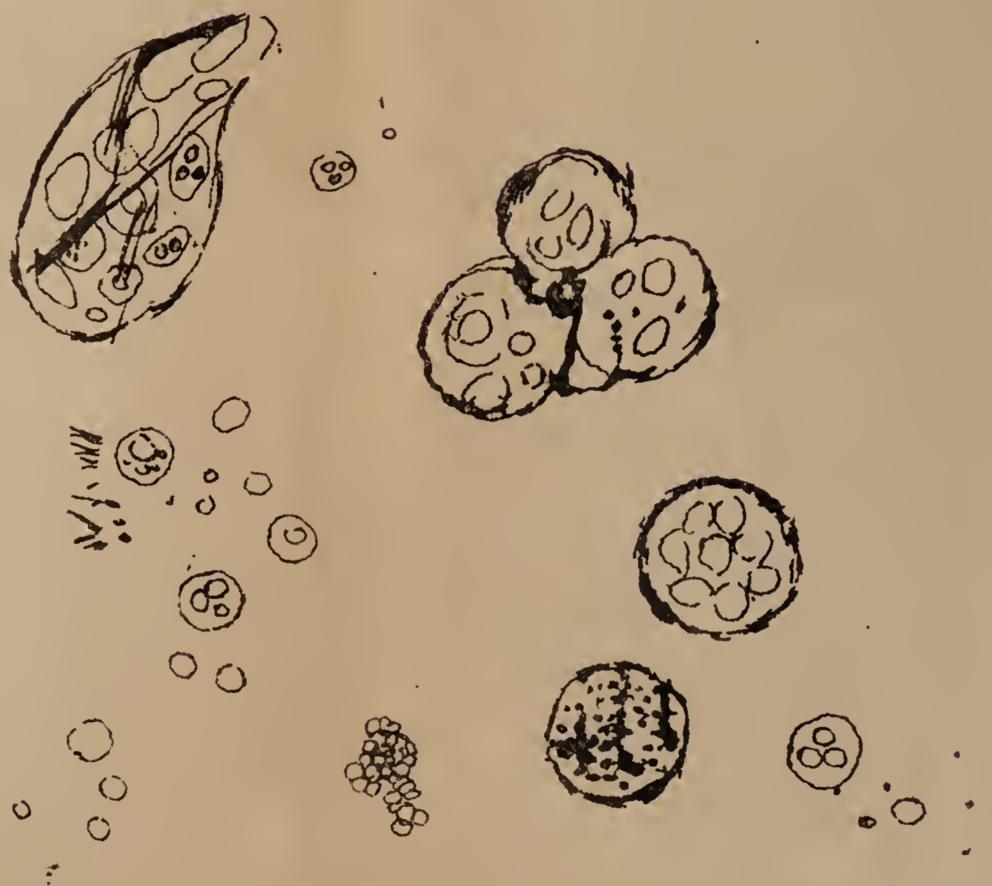
9



10



11



12